

Prosthetic rehabilitation in neurosurgical cranioplasty

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Abstract

The defects of the skull cause mechanical vulnerability of the brain, esthetic disfigurement, and transmission of vibrations and pulsation of the brain. Subsequent cranioplasty may be required to compensate for the defect and to alleviate various signs and symptoms. When long-term outcome of biomaterial use in pediatric cases is limited, alloplastic cranioplasty in adults are supported by several large case series. This case report narrates cranioplasty using titanium alloplastic implant material.

Keywords: Cranioplasty, prosthesis, reconstruction, titanium implants, trauma

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INTRODUCTION

Cranial defects may develop from various causes such as congenital and acquired defects such as surgery, trauma, and pathological diseases.^[1] Such defects are treated using cranioplasty to shield the underlying brain tissues. It also aids in relieving pain and better appearance leading to improved quality of life. Minor defects of 2–3 cm dimension located immediately above the orbital rim or nasion may require correction entirely for cosmetic reasons. However, defects of more than 8 cm in dimension at the posterior parieto-occipital junction may require repair almost entirely for the purpose of brain protection.^[2] The indications for cranioplasty include the social stigma due to disfigurement, mechanical vulnerability, painful postsurgical cranial defects, and those defects which cannot be repaired by other surgical techniques.^[3] There are two methods of cranial reconstruction, namely, osteoplastic reconstruction and other using alloplastic implants. The technique adopted by neurosurgeon is the use of decompressive

craniectomy (DC) with duraplasty for life-threatening raised intracranial pressure in traumatic brain injury cases. The benefit of DC is reasonably well-documented worldwide. Autogenous bone, alloplastic materials including metals, heat-polymerizing acrylic, polyethylene, and silicone are usually used materials.^[2,3] However, polyether ether ketone (PEEK) is a recently introduced material for cranioplasty which is a proved successful implant material in orthopedics as well. Titanium has been used recently in fabricating cranial prostheses. This metal is strong, but light material which is soft enough to be swaged in a die-counter-die system. Moreover, it can be strain hardened and thus becomes stronger with manipulation. Sheets which are 0.61 mm thick are adequate, and its radiodensity permits most radiographic studies. After the metal prosthesis is shaped, trimmed, and polished, tissue acceptance of the implant is enhanced by anodizing it in a solution of 80% phosphoric acid, 10% sulfuric acid, and 10% water. Hence, this article describes a technique

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of cranioplasty using titanium implants which is found to be biocompatible, lightweight, and clinically stable. Cranial prosthesis can be made from casts derived by rapid prototyping techniques.

CASE REPORT

A 23-year-old male patient reported to the Department of Prosthodontics, Government Dental College. He was referred from the Department of Neurosurgery, Medical College for rehabilitation of postsurgical defect on the left side of the head caused from firework tragedy [Figures 1-3]. The tragedy resulted in an open head injury with left temporoparietal contusion and a fracture of the squamous part of the temporal bone. Postoperatively, it was found that the patient had a large bony defect on the left side of the skull with no sensorineural dysfunctions. On examination, the defect was found to be approximately 15 cm × 12 cm in size. He was a college-going student and was more concerned about esthetic recontouring of the defect, and it was of utmost challenge. The defect that was to be restored was large, and a computer-aided design and

computer-aided manufacturing (CAD/CAM) prosthesis would have been the most probable option, but considering the economic background of the patient, a custom-made titanium cranial prosthesis was planned and was fabricated to recontour the cranial defect.

For fabrication of prosthesis, outer and inner margins of the defect were located and marked with the help of neurosurgeon before impression making. Irreversible hydrocolloid (Alginate) was mixed vigorously with cold water and spread out over the scalp area. Cotton gauze was partially embedded. After setting, 2–3 layers of quick setting plaster was poured to achieve a firm base [Figure 4], and the impression was removed and poured in dental stone (kalstone) [Figure 5]. As per the instructions of neurosurgeon, markings were made 5 mm beyond the edge of the defect, so that 2-mm diameter holes can be placed to fix the prosthesis with titanium implant.

The cast was then painted with a suitable separating medium. Molten wax was poured into the defect for the



Figure 1: Preoperative photographs showing left cranial bone defect (frontal view)



Figure 2: Preoperative photographs (lateral view)

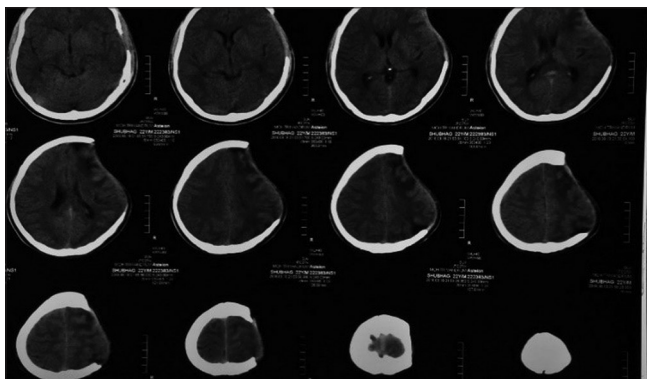


Figure 3: Computed tomography with skull defect



Figure 4: Impression of the defect

fabrication of a wax pattern, and it was carved out from inside to simulate the thickness of the bone [Figure 6]. The wax over the defect in cast model was carefully contoured and tried for bilateral symmetry. The wax pattern was retrieved and used for the fabrication of titanium mold using a 1.2-mm thick titanium alloy (Ti6Al4V) plate. The titanium plate is not made for full thickness of wax pattern; instead, the outer contour only is simulated. The minimum thickness of the titanium mold is 0.5 mm. The manufacturing process was carried out by applying pressure on titanium plate, which was exerted by two pieces of Duraluminum in which the wax pattern of implant was machined. In the titanium implant, 2-mm holes were drilled with same drill bits throughout the plate as per the instructions of neurosurgeon and were tried extracranially [Figure 7]. Sterilization of implant was done as per the theater sterilization protocol. The patient was under general anesthesia and frequently monitored in the surgical theater. Peroperative, after reflection of flap [Figure 8] and exposure of the bony defect, the implant was made

to seat in the defect properly [Figure 9]. The screws were tightened into the holes to secure implant into position, and the flap was sutured back into position [Figure 10]. Sutures were removed on the 7th postoperative day, and the patient was discharged with uneventful healing. The reestablished cranial contour was well appreciated during follow-up [Figures 11 and 12].

DISCUSSION

The physical and mechanical properties of materials used for the fabrication of maxillofacial prosthesis influence success of prosthodontic treatment. The materials commonly used for fabrication of these prosthesis are acrylic resins, acrylic copolymers, various metals, vinyl polymers, polyurethane elastomers, silicone elastomers, and PEEK.^[4] However, none of them fulfill all the requirements for a satisfactory prosthesis.^[5] The flexibility, good surface texture, and lifelike appearance of silicone make it the most widely used material for fabrication of maxillofacial



Figure 5: Retrieved cast



Figure 6: Wax pattern of the defect



Figure 7: Extracranial tryin of titanium plate

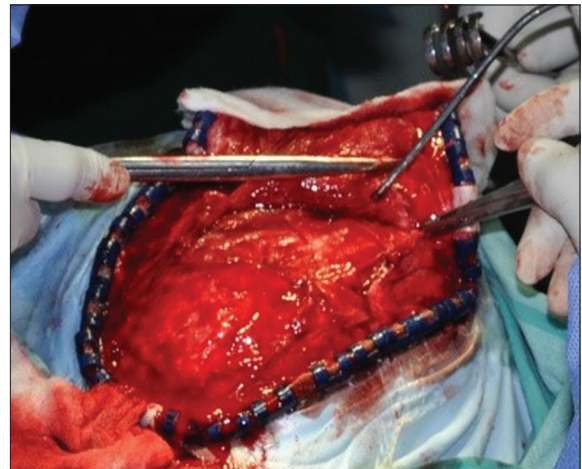


Figure 8: Neurosurgical procedure

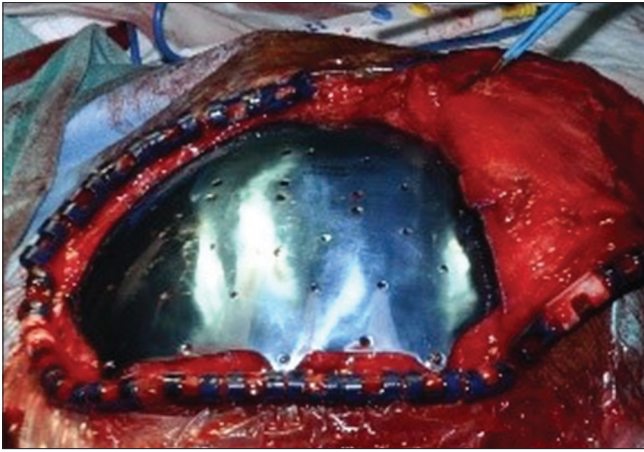


Figure 9: Neurosurgical procedure showing titanium implant in position



Figure 10: Sutures placed



Figure 11: Postoperative view showing excellent adaptation and symmetry



Figure 12: Postoperative aerial view

prosthetic material.^[6-8] Recently, CAD/CAM system for fabrication of oral and maxillofacial prosthesis is being used. However, its complexity, cost, and nonavailability at many centers is a limitation.^[7] The advantages of cranioplasty include not only the anatomic accuracy but also the esthetic contouring as well as maintenance of hemodynamics. Most cranioplasty materials are used with little adjustments by the surgeon. However, the basic principle should not be forgotten; to choose proper material for the defect. A cranioplasty material must have low infection rates, show low heat conduction, to be nonmagnetic, radiolucent, tissue acceptable, durable, shapable, and inexpensive.^[9] Before achieving bone closure, clear bone borders should be obtained, and scalp should be dissected from dura. Dural tears should be closed in watertight manner. Bone and cranioplasty material should touch to each other with maximum capacity. To prevent the mobility of the cranioplasty flap, the material is fixed to the bone with proper plates. Prefabrication of polymethyl methacrylate (PMMA) prostheses by hand has been used

since the 1970s employing various procedures, but these methods appear to have been shadowed by newer CAD/CAM techniques,^[10] which basically consist of using imaging from the patients' cranial defect and prefabricating the PMMA prosthesis using a three-dimensional (3D) printer. Certainly, the use of these techniques becomes a challenge for developing and third-world countries, in which limited economic and logistical resources do not allow for the extensive use of such technology. With retrospective studies, titanium has proved to be an excellent material for cranioplasty, especially with the appropriate technology for preparation.^[11] Precise communication between the neurosurgeon, maxillofacial surgeon, and prosthetist to give individual consideration of the patient's defect, plate design, and orientation is essential. The custom-made implants for cranioplasty showed a significant improvement in morphology.^[12] The implants may be very useful for repairing large- and complex-shaped cranial defect. Using a 1.2-mm thick titanium alloy (Ti6Al4V) plate, the implant was fabricated. The manufacturing process was carried out

by applying pressure on titanium plate, which was exerted by two pieces of Duraluminum in which the wax pattern of the implant was machined. In the titanium implant, 2-mm holes were drilled with same drill bits throughout the plate as per the instructions of neurosurgeon. Titanium mold was perforated uniformly, in this case, to prevent fluid accumulation beneath the prosthesis, and enhance lymphatic drainage, to ensure growth of fibrous connective tissue into the holes for better adhesion of scalp over the prosthesis and also to prevent accumulation of epidural hematoma.^[13] Titanium is well established in the field of cranial and craniofacial medicine. This is primarily due to its biological inertness, favorable strength-to-weight ratio, and favorable cosmetic and functional outcomes. Another key advantage of titanium is its natural osseointegration factor, which promotes active bone growth into the implant. Despite its lower Young's modulus than alternative metals, the value for titanium is higher than that of natural bone, leading to a lessened, but still present, risk of stress shielding. Titanium implants will often require prefabrication leading to an increase lead time and cost. In addition, intraoperative alteration remains difficult. Studies have shown that titanium implants for cranial and maxillofacial applications have a lower survival rate (higher complication rate)^[14] than alternative materials such as PMMA. The manual techniques used are often doubtful about its fit and tissue growth. Autografts, allografts, xenografts, celluloids, methyl methacrylate, hydroxyapatite, silicone, ceramic, metal allografts such as aluminum, gold, silver, palladium, tantalum, and titanium are being used and among this due to various properties of titanium as discussed, they are used for cranioplasty widely. Recent technologies such as 3D computed tomography (CT) and stereolithographic models evaluate the exact volume and contour of the defect and thus ensure exact fit of the prosthesis. However, considering the economic status

of the patients, clinicians are often forced to deliver prosthesis using manual methods. Thus, rehabilitation of cranial defect with titanium implants is often a challenge to us. Adequate rehabilitation of skull disfigurement with regained strength on left side of the skull was the highlight of this case report.

CONCLUSION

Number of patients requiring cranioplasty has increased considerably in recent years due to large number of cranial injuries occurring in this modern age. This case report illustrates a patient, who was a victim of firework tragedy. His defect was corrected by initial surgical correction and cranioplasty with titanium implant. Ongoing researches on both biologic and nonbiologic substitutions continue with the help of recent technology. Stem cell experiments and development of morphogenic proteins are expected to take place in the short-term future. This case has been reviewed after 2 months, and later, follow-up was done again after 8 months [Figures 13 and 14]. The patient did not report any complications till date and CT scan after 10 months revealed perfect adaptation of mold to the skull without any abnormal findings [Figure 15]. The results were appreciable.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the journal. The patient understand that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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Nil.



Figure 13: Follow-up 8 months



Figure 14: Follow-up 8 months

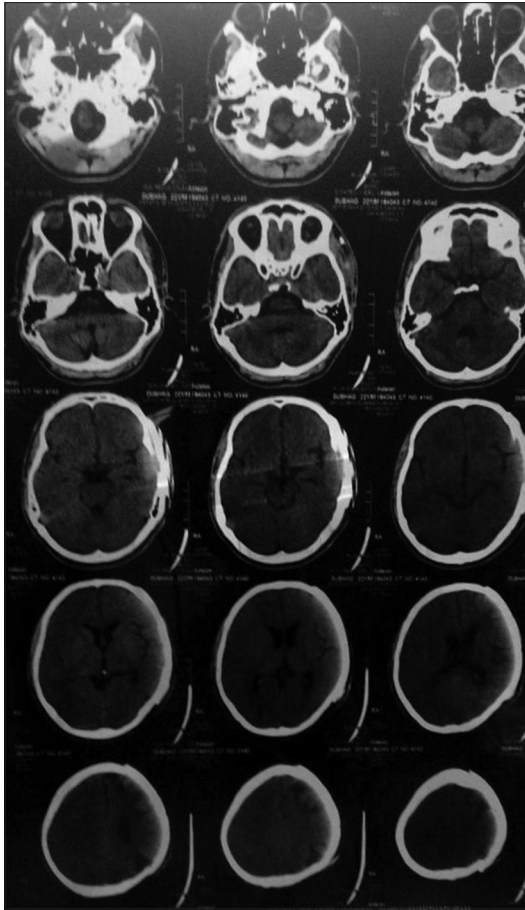


Figure 15: Computed tomography scan after 10 months

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Pavaiya A, Tyagi VK, Tripathi A, Singh SV, Chand P. Cranioplasty with

- alloplastic cranial implant. *J Indian Prosthodont Soc* 2009;9:109-11.
2. Ebrahimi A, NejadSarvari N, Rasouli HR, Ebrahimi A. Warfare-related secondary anterior cranioplasty. *Ann Maxillofac Surg* 2016;6:58-62.
3. Goiato MC, Pesqueira AA, dos Santos DM, Antenucci RM, Ribeiro Pdo P. Evaluation of dimensional change and detail reproduction in silicones for facial prostheses. *Acta Odontol Latinoam* 2008;21:85-8.
4. Punchak M, Chung LK, Lagman C, Bui TT, Lazareff J, Rezzadeh K, et al. Outcomes following polyetheretherketone (PEEK) cranioplasty: Systematic review and meta-analysis. *J Clin Neurosci* 2017;41:30-5.
5. Alqutaibi AY. Materials of facial prosthesis: History and advances. *Int J Contemp Dent Med Rev* 2015;2015:4.
6. Mortellaro C, Garagiola U, Lucchina AG, Grivetto F, Milone G, Pappalardo S, et al. The use of silicon elastomer in maxillofacial rehabilitation as a substitute for or in conjunction with resins. *J Craniofac Surg* 2006;17:152-62.
7. Tsuji M, Noguchi N, Ihara K, Yamashita Y, Shikimori M, Goto M, et al. Fabrication of a maxillofacial prosthesis using a computer-aided design and manufacturing system. *J Prosthodont* 2004;13:179-83.
8. Kharade P, Dholam K, Gorakh A. A technique for fabrication of cranial prostheses using high-temperature vulcanizing silicone material. *J Prosthet Dent* 2017;118:113-5.
9. Seckin A, Baris K. Cranioplasty: Review of materials and techniques. *J Neurosci Rural Pract* 2011;2:162-7.
10. Mathew N, Joseph S, Joseph AM, Koshy AT, George R. Rehabilitation of a craniofacial defect using extra-cranial prosthesis. *J Int Oral Health* 2016;8:813-6.
11. Piazza M, Grady MS. Cranioplasty. *Neurosurg Clin N Am* 2017;28:257-65.
12. Goiato MC, Pesqueira AA, Ramos da Silva C, Gennari Filho H, Micheline Dos Santos D. Patient satisfaction with maxillofacial prosthesis. Literature review. *J Plast Reconstr Aesthet Surg* 2009;62:175-80.
13. Parichay PJ, Khanapure K, Joshi KC, Aniruddha TJ, Sandhya M, Hegde AS, et al. Clinical and radiological assessment of cerebral hemodynamics after cranioplasty for decompressive craniectomy – A clinical study. *J Clin Neurosci* 2017;42:97-101.
14. Le C, Guppy KH, Axelrod YV, Hawk MW, Silverthorn J, Inacio MC, et al. Lower complication rates for cranioplasty with peri-operative bundle. *Clin Neurol Neurosurg* 2014;120:41-4.